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(54) APPARATUS AND METHOD FOR THE VIBRATORY FEEDING OF PULVERULENT AND GRANULAR MATERIALS

(71) We, FRED S. CARVER INCORPORATED, a corporation organized and existing under the laws of the State of New York, United States of America, of West 142 North 9050 Fountain Boulevard, Menomonee Falls, Wisconsin 53051, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus and method for the vibratory feeding of pulverulent and granular materials.

The discharge of pulverulent and granular materials from hoppers and chutes has often presented a difficult problem. In particular, where the material has oils and/or greases as either natural or added ingredients the free flow of the material is usually non-existent. The use of some kind of vibratory means to induce or accelerate the flow of pulverulent material such as face powder, flour and the like is well known and has been disclosed in many patents. The known apparatus usually contemplates a vibratory system of fixed frequency and amplitude. Such apparatus may prove to be workably adequate until the flow characteristics of the material sought to be dispensed change. That change may occur because of temperature and/or humidity variations and/or because of inconsistencies in the preparation of the pulverulent material. When a precise quantity of material is to be dispensed at a given flow rate the known vibratory feeders usually are less than fully satisfactory.

Among the several patents showing vibratory systems in the general area of the present invention are US Patent No. 2 353 492 to J C O'Connor; US Patent No 3 053 379 to J Roder et al; US Patent No 3 346 097 to R M Carrier, Jr.; US Patent No 3 407 670 to M Venanzetti, and US Patent No 3 449 969 to M T Dorris. In the systems disclosed there and in other known vibratory systems using two parallel shafts having eccentric weights it has been explicitly described as desirable to have those shafts rotate at the same speed so as to amplify the vibratory action. This produces standing wave patterns in the material being dispensed. As will be described subsequently, this can be avoided in embodiments of the present invention by positively driving two shafts at different speeds.

In the pressing of face powder into godets, the powder-holding devices used in ladies' compacts or vanity kits, a precise filling technique is necessary if the resulting filled godet is to become a consistently attractive finished product after compaction of the powder in it. Auger type of filling equipment tends to be inconsistent in the amount of powder which it places in the receptacles per unit time. This inconsistency is particularly prevalent where the material has a high content of binders such as oil, water or wax and bridges heavily. On the other hand, notably, when vibration is added or is used as the primary source of movement the particular and peculiar resistance of the pulverulent mixture to flow usually causes a balling of the mixture rather than a flow.

According to the present invention there is provided a method for the vibratory feeding of pulverulent and granular materials, by imposing on a body of said material a vibration comprising at least two different non-harmonic frequencies, such that the material is fluidised and can be fed in a substantially liquid-like manner.

According to the present invention there is also provided apparatus for the vibratory feeding of pulverulent and granular materials, said apparatus comprising (1) a hopper disposed to be supplied with and at least transiently contain pulverulent or

granular materials and having a lower end in which there is an outlet opening through which said materials may be discharged; (2) resilient support means for said hopper so configured to permit the hopper to be vibrated in six degrees of free movement, and (3) means for imposing vibration comprising at least two different non-harmonic frequencies upon said hopper and through it upon granular or pulverulent material contents thereof causing said contents to be fluidised whereby said material is induced to feed to and discharge from said outlet opening of said hopper in substantially liquid-like manner.

To provide a satisfactory filling technique with vibration, embodiments of the present invention contemplate that at some frequency peculiar to the particular pulverulent material being handled that material behaves substantially as a liquid, and loses the characteristic of an angle of repose normally associated with it. Where a precise delivery to a plurality of cavities or receivers below a feed hopper is contemplated, it has been found efficient and desirable to transmit the vibratory energy to vanes or dividers of relatively short length within the hopper and disposed closely above the receiving means. To obtain an efficient transfer of energy from the source of power to the pulverulent material, a six-degree of freedom support is provided for the hopper which is usually flexibly connected to other apparatus.

Synchronised vibratory systems tend to generate standing waves in pulverulent materials or powders being dispensed, and in embodiments of the present invention they are sought in particular to be avoided. Standing waves cause dead spots within filling columns which affect the fluid flow of the material. In the illustrated apparatus embodiment of the present invention the power drive pulley has two grooves of different sizes driving like-sized pulleys on the parallel shafts of the vibrator or shaker mechanism. That causes the platform on which the feed hopper is mounted and hence the hopper itself to have one side shake at one frequency while the opposite side of the hopper is being shaken at another frequency. In the course of being shaken at two dissimilar frequencies at the same time, the active portion of the six-degree of freedom hopper is also influenced by the additive and the subtractive frequencies between the two fundamentals.

The imposition of those frequencies prevents creation of standing waves in pulverulent material in the active portion of the hopper, and enables and indeed causes that material to behave essentially as a liquid when the vibratory energy is put into it at a particular frequency, that is the fluidic frequency, peculiar to that material. Preferably one of the imposed fundamental frequencies is above the fluidic frequency of the pulverulent material and the other imposed frequency is below it. Each pulverulent and granular material appears to have its own characteristic viscosity when it is in a fluidised condition; that is, when it is subjected to vibration at its fluidic frequency and then caused or allowed to flow essentially as a liquid.

Embodiments of the present invention effectively permit or cause the substantially fluid movement of materials such as cosmetic powders, pharmaceutical powders, granulated iron ore, foundry sand, milk powders and resinuous or plastics powders, to name only a few of many difficult to dispense pulverulent and granular materials amenable to being processed hereby. Additionally they permit the successful use of feeding channels having high aspect ratios, that is plan ratios of length to breadth, such as ratios up to about 5:1. Correspondingly it allows successful filling of powder receiving containers having high aspect ratios, or characterised by small-angle corners or cusps or which are otherwise unusually configured. An example is a heart-shaped container for cosmetic powder. None of that is possible, at least not easily possible, when traditional means for feeding pulverulent and granular materials are used which do not call for thoroughly randomised fluidisation of those materials such as is obtainable through employment of embodiments of the present invention.

The invention will now be further described by way of example with reference to the accompanying drawings, in which:—

FIG. 1 represents a side view of a preferred embodiment of the vibratory feeder apparatus of this invention, showing in particular a substantial portion of the drive arrangement for the eccentrically weighted shafts and the suspension or support system for the feed hopper;

FIG. 2 represents a plan view of the apparatus of FIG. 1 taken along line 2-2 therein looking in the direction of the arrows with portions of the drive pulley members shown in section to illustrate clearly the two drive systems distinct as to output speeds provided at the eccentrically weighted shafts as developed from a single motor having a selectively variable speed;

FIG. 3 represents an exploded isometric view of most of the several components which comprise the drive system or systems for the eccentrically weighted shafts;

FIG. 4 represents a sectional view in side elevation of the electric clutch used in the drive system of the apparatus of FIG. 1;

FIG. 5 represents an exploded isometric view of the feed hopper and its spring suspension or support system;

FIG. 6 represents an isometric view of the feed hopper and its support plate showing in particular the two eccentrically weighted shafts actuated by the drive system and mounted in bearings on the hopper support plate, a portion of the hopper being broken away to show an internal divider arrangement for separating the pulverulent material discharge from the hopper into four streams;

FIG. 7 represents an isometric view of the motor support and drive shaft arrangement for providing differential speeds to the eccentrically weighted shafts;

FIG. 8 represents a sectional view in slightly enlarged scale taken along line 8-8 in FIG. 7 looking in the direction of the arrows of the drive pulley and the belt drives or driving belts providing the two positively different speeds of the eccentrically weighted shafts;

FIG. 9 represents an isometric view of the feed hopper and its support plate, the hopper being partly broken away;

FIG. 10 represents a plan view of the hopper of FIG. 6 but including an internal divider arrangement for separating the pulverulent material discharge from the hopper into two streams;

FIG. 11 represents an isometric view of the divider device used to achieve the two-stream division of pulverulent material discharge according to the hopper arrangement of FIG. 10;

FIG. 12 represents a plan view of the feed hopper of FIG. 9 but including an internal divider arrangement for separating the pulverulent material discharge from the hopper into three streams;

FIG. 13 represents an isometric view of the divider device used to achieve the three-stream division of pulverulent material discharge according to the hopper arrangement of FIG. 12, and

FIG. 14 represents a front or face view of the vibratory feeder apparatus of the present invention mounted as part of a cosmetic powder godet filling and pressing apparatus.

Referring now to the drawings in detail especially to FIGS. 1 and 2 thereof, a supply hopper 20 supported by means not shown in detail is joined by means of a flexible collar 21 to a vibratory feed hopper 22 mounted to be moved or shaken in six degrees of freedom. Attached to and extending normally outwardly from hopper 22 fairly close to the lower end thereof is a flange-like support plate 23 which is mounted resiliently upon four coil-wound compression springs 24. Those springs in turn rest upon a foundation plate 26 which is slidably mounted in grooves defined in side block portions 27 of a base 28. Four spacers 30 are provided for the support and positioning of that base from apparatus which uses or further processes the pulverulent and/or granular material dispensed by the vibratory feeder.

An electric motor 32 is carried by a bracket 34 which is supported by and attached to a mounting block 35 in turn attached to foundation plate 26. A shaft housing 36 is carried by and attached to mounting block 35 and rotatably retains drive shaft 38 at an established distance above plate 26. A single-groove pulley 40 mounted on motor shaft 41 is disposed to accommodate a round belt 42 which rotates or drives another single-groove pulley 44 carried on the right-hand end of drive shaft 38. An electrically actuated clutch 46 is also carried on drive shaft 38, and is disposed to engage and disengage the driving force available to be imparted to shaft 38 from and by the rotation of pulley 44. On the end of motor shaft 41 just inside single-groove pulley 40 there is a relatively heavy metal disc 47. This disc is of sufficient mass to serve as a flywheel for motor 32 and ensure that the speed of the motor does not change excessively when clutch 46 is engaged and disengaged for the purpose, ultimately, of imposing vibrations upon hopper 22 during selected periods of time.

Referring now in particular to FIG. 2, a double-groove pulley 48 is shown mounted on the left end of drive shaft 38, and it is driven by that shaft. The grooves in pulley 48 are of different pitch diameters, and are disposed to drive round belts 49 and 50 at different rates of linear speed. Those belts pass respectively around pulleys 52 and 53 which are identical and are turned at different angular speeds because of the difference between the linear speeds of their driving belts. Pulleys 52 and 53 are respectively mounted on and impose rotation upon identical shafts 55 and 56 which are carried in pairs of bearing blocks 58 located on the upper surface of hopper support plate 23. There is an eccentric weight 60 attached near each end of each of shafts 55 and 56 beyond the bearing block 58 close to that end, and indeed beyond pulleys 52 and 53 in the regions of the shaft ends where those pulleys are located. *S*-shaped flow divider 112 within feed hopper 22, its mounting screws and nuts 114 and 115 and filling apertures or receptacles 110 below the hopper, all shown in FIG. 2, are discussed in detail in connection with FIG. 6.

Referring next to FIG. 3, there is shown the drive for the vibratory feeder which originates with variable speed motor 32. That motor itself is set to run at a selected speed through control means not shown. Motor shaft 41 carries flywheel 47 and pulley 40 (see FIGS. 1 and 2), and belt 42

extends from driving pulley 40 to driven pulley 44. Electrically actuated clutch 46 is carried on shaft 38 and is disposed to the right of shaft housing 36. Sleeve bearings 61 and 62 are press fitted into counterbored regions at the ends of bore 63 in housing 36, and are sized rotatably to retain shaft 38. Pulley 48 has two grooves of different pitch diameters as aforesaid, and is mounted on the left-hand end of shaft 38 and is rotated with that shaft when clutch 46 is engaged.

Shafts 55 and 56 are each carried on a pair of aligned bearing blocks 58. Shouldered sleeve bearings 65 are press fitted into bores 66 formed in those blocks. Pulley 52 is fixed to shaft 55 near its right-hand end, and pulley 53 which is identical in dimensions to pulley 52 although turned to the opposite hand from it is fixed to shaft 56 near the right-hand end thereof. Belt 49 passes around pulley 48 and pulley 52, while belt 50 passes around pulley 48 and pulley 53. Belt 49 runs in the right-hand groove of pulley 48 while belt 50 runs in the left-hand groove of that pulley. The right-hand groove of pulley 48 is considered to have a somewhat smaller pitch diameter than the left-hand groove. Two eccentric weights 60 are mounted on shaft 55 with one weight located fairly close to each end of that shaft. These weights are orientated selectively to provide such intensity or amplitude of vibration as may be required to provide satisfactory fluidic or liquid-like flow of the particular pulverulent material being handled. Two eccentric weights 60 are also mounted on shaft 56 and oriented thereon according to the same principle or object.

Referring next to FIG. 4, the electric clutch assembly shown in detail therein includes a flanged end 70 which is attached by screws to shaft housing 36. Within that end there is a magnet coil 72. Coil leads 74 and 75 extend through and from the flanged end and are connected to a electrical control system not shown. Drive flange 76 is carried by and secured to shaft 38, and imparts rotative torque to that shaft when the clutch is engaged. Pulley 44 has bushings or bearings 78 and 79 press fitted into it, and those bushings have a free running fit on shaft 38. A clutch ring or clutch face 81 is mounted on a thin spring plate or spring disc 82 fastened to the left hand or hub portion of bushing 78. Thus pulley 44, bushings 78 and 79, clutch ring 81 and spring disc 82 turn as a unit as they are driven by motor 32 through pulley 40 and belt 42. A nut 85 and washer 86 on shaft 38 serve to retain pulley 44 and its associated parts on that shaft, at least so far as any undue rightward movement of them is concerned.

Assume that motor 32 is in operation, and accordingly that pulley 44, bushings 78 and 79, spring disc 82 and clutch ring 81 are being located. Assume further that no power is being applied to magnet coil 72. The illustrated clutch, clutch 46, thus is not engaged and so drive flange 76 and shaft 38 are at rest while pulley 44 and its associated parts are turning with respect to that shaft. Now assume that magnet coil 72 is energized. Magnetic clutch ring 81 will be attracted to the left to come into contact with and achieve a torque-transmitting engagement with the right hand face of shaft drive flange 76, especially at friction ring 83 set in that face. This will happen either by pulley 44 and its associated parts all being moved slightly to the left or else by flexure of spring disc 82 if leftward movement of bushing 78 be prevented by a shoulder on shaft 38.

At any rate, whatever the precise mechanical or electro-mechanical action, clutch ring 81 will be held in torque-transmitting engagement with shaft drive flange 76 and through it with shaft 38 so long as magnet coil 72 is energized. When that energization is terminated the aforesaid torque-transmitting engagement will cease and shaft 38 will come to rest, actually practically at once because of the load on it, while motor 32, pulley 40, belt 42, pulley 44 and the parts associated with the last-mentioned pulley may all continue to turn or run. The structure and the mode of operation of clutch 46 have been illustrated and described in some detail, but only for purposes of example and to show the function of the clutch in association with other apparatus components.

Referring next to FIG. 5, foundation plate 26 which carries vibratory feed hopper 22, support plate 23, motor bracket 34 and other parts illustrated and described earlier, is of such thickness and width to be slidably received and retained for about half its length in grooves 90 and 91 defined in side block portions 27 of base 28. The four identical spacers 30 extending below base 28 are of rigid material, for example metal, and their length is such to give proper vertical location to the feeder assembly with respect to the apparatus below it with which it is operatively associated. Fastening devices not shown pass through base 28 near the ends of the side block portions thereof, then through spacers 30 and into the associated apparatus. In an embodiment of this invention there is a turntable provided with apertures and otherwise configured to convey receptacles, specifically cosmetic powder godets, to be filled with pulverulent material. This turntable is supported closely above and driven through a stationary plate extending horizontally beyond the periphery of the turntable and upon which spacers 30

rest in attached relationship, with the portion of foundation plate 26 not directly above base plate 28 so oriented to overhang the turntable.

It should be noted in FIG. 5 that one edge of base plate 28 is of arcuate contour. That edge has essentially the curvature of the periphery of the turntable adjacent it, and the upper surface of the base plate is essentially flush with the upper surface of the turntable. Foundation plate 26 and all the mechanism attached onto and above it may be removed from the turntable and other components of the overall godet filling apparatus by sliding it to the right through and out of grooves 90 and 91 in base plate side blocks portions 27 according to the disposition of parts in FIG. 5 and indeed in other Figures such as FIGS. 1 and 2. A gasket 100 discussed hereinafter which extends below foundation plate 26 in the normally overhanging region thereof to bear at least slightly compressively on the turntable will simply wipe directly across the adjacently flush surface of base plate 28. Reinstallation of foundation plate 26 and the mechanism which it carries may be effected simply by just the reverse method, that is, by sliding that plate into grooves 90 and 91 from the right moving to the left until the correct overhang of plate 26 with respect to the turntable is achieved. Positive fastening means for plate 26 in grooves 90 and 91 preferably are provided, although if that plate have a snug sliding fit in those grooves it will tend generally to remain in the location in which it is placed relative to fixed structure such as base plate 28, and fastening means of the kind described may not be needed in some instances as a practical matter.

There are four holes 93 in hopper support plate 23 near the corners thereof. Those holes accept and in them are retained the upper ends of springs 24. The lower ends of those springs are located definitely on foundation plate 26 by means of round head cap screws 95 threaded into tapped holes 97 in the foundation plate. Washers 99 are carried by screws 95 and are so sized to engage and retain the lowermost turns or coils of springs 24 against the upper surface of plate 26 when the screws are tightened. An aperture 104 is defined in the left hand portion of foundation plate 26, that is, the portion of that plate overhanging the turntable in the mechanical construction or assembly described above. Aperture 104 is similar in configuration to the plan cross section of feed hopper 22 but is larger. Thus as hopper 22 and plate 23 are supported by springs 24 the lower end of the hopper may extend into aperture 104 without coming into contact with the defining surfaces thereof. Within the ranges that springs 24 and the clearance of the hopper within the aperture permit, therefore, the assembly of feed hopper 22 and its support plate 23 may move or be moved resiliently with up and down, side to side and end to end motions in translation and oscillated about X-, Y- and Z-axes in rotation to perform motion in six degrees of freedom with respect to foundation plate 26.

A gasket 100 of foam rubber or other material of semi-flexible and resilient nature extends through foundation plate aperture 104 and surrounds the extreme lower portion of feed hopper 22 including its outlet end or discharge region. The gasket is held down by four clips or brackets 102 attached to plate 26 around aperture 104. These clips bear on the gasket's upper surface. The lower surface of the gasket which is below the discharge end of hopper 22 is disposed to have rubbing contact with the aforementioned turntable under some noticeable contact pressure so that the gasket is compressed vertically at least slightly. Thus as pulverulent material pours down through feed hopper 22 onto the turntable the gasket provides a seal against that material spreading out laterally on the turntable. It also seals against such material rising up around the outside of the hopper. Of course as feed hopper 22 is vibrated and moves with six degrees of freedom its lower end is changing position and orientation continuously if only slightly with respect not only to foundation plate 26 but also any turntable below that plate. The compression in gasket 100 as installed, however, is such that both aforementioned seals are maintained steadily even as the hopper is vibrated by rotation of the eccentric weight shafts 55 and 56 mounted on support plate 23.

Referring next to FIG. 6, vibratory feed hopper 22 appears with a substantial portion of it above support plate 22 broken away to show certain interior arrangements of the hopper. A portion of the support plate is broken away also. Bearing blocks 58 are mounted on plate 23 and carry shafts 55 and 56 which in turn carry eccentric weights 60. Motor 32 supported on bracket 34 drives the eccentric weight shafts through belts 49 and 50, and a portion of belt 50 is visible behind the hopper. Eccentric weights 60 mounted on shaft 56 are shown as being oriented at approximately ninety degrees to each other. That orientation is used only for purposes of illustration and example and not of limitation. As shown in FIG. 6, hopper 22 is disposed to feed pulverulent material into four grouped oblong apertures 110 (see also FIG. 2) defined in structure or apparatus not further illustrated. That apparatus may, however, be taken to be the turntable mentioned earlier, and the apertures considered as being formed in the

turntable itself or else representing the interior boundaries of cosmetic powder godets or other pulverulent material receiving means set within apertures in the turntable.

A divider 112 of relatively stiff but still resilient material, for example spring steel, is mounted within hopper 22 and configured to separate or divide the lower, discharge end of the hopper effectively into four parallel passageways. In plan view the divider is of a rectangular *S* configuration and is attached at its reversals to opposite interior surfaces of the hopper. The end elements of the divider are slightly shorter than the interior dimension of the hopper parallel to shafts 55 and 56 (see FIG. 2) leaving those elements free to vibrate somewhat in the nature of tuning fork prongs or cantilevers. Screws or bolts 114 pass through clear holes 116 (see FIG. 9) in opposite walls of feed hopper 22 and also through vertically elongated clear holes 118 in the reversal segments or sections of divider 112, in one case through a vertical tab extension of such segment, and are provided with nuts 115 to be tightened to retain the divider within the hopper at a position limitedly adjustable in height on account of the elongation of holes 118. The vertical tab extension of one of the reversals of the divider, and corresponding raising of the associated hole 116 in hopper 22, serves simply to bring one of the screws 114 to a convenient height for manipulation clear of motor 32.

Suppose that electric motor 32, preferably a variable speed motor, has been turned on, and shafts 55 and 56 with their eccentric weights 60 are being rotated at different speeds. Vibrations will be imposed upon support plate 23 and feed hopper 22 and through the hopper upon divider 112, especially the free end elements thereof. At the proper adjustment of angular speeds of the shafts and their weights, the divider end elements may be made to vibrate significantly within the hopper, their individual vibrations being in addition to the gross vibration of the hopper itself. With feed hopper 22 being continuously replenished with pulverulent material from supply hopper 20 (see FIG. 1) so that some material is maintained within the feed hopper, the vibrations of the end elements of divider 112 will assist in achieving and maintaining fluidity of the material in that hopper, and particularly aid in establishing full and even flow rates of all four streams of pulverulent material being discharged from the hopper into apertures 110 to assure uniform filling of those recesses or apertures or any receiving means set within them.

When the vibratory feeder apparatus is operating or being operated at frequencies appropriate to the pulverulent or granular material being fed, the entire surface of the body of material within feed hopper 22 will appear to be practically alive as the material is fluidized. That condition, in which there are no alternately dead and active regions at the material surface and particularly no visible agglomerations of material, is not contingent upon the presence of divider 112 or some other divider in the lower, outlet end of the feed hopper, but is obtainable through vibration of support plate 23 and hopper 22 only. Since vibrations of those members are being forced by power-driven eccentric weights 60, consistently reliable fluidization of the pulverulent material is not defeated by any damping action of flexible collars or gaskets 21 and 100 respectively at the upper and lower ends of the feed hopper. In specialized situations, however, for example feeding into multiple apertures or receptacles as shown in FIG. 6, together with requirements to feed especially waxy or oily pulverulent materials, use of vibratory dividers may assist in the achievement of fluidity for a limited range of speeds of motor 32 and in maintaining uniformity of fluidization.

Referring next to FIGS. 7 and 8, the assembly and details of the power train for the vibratory feeder may be seen in the extent of that train between electric motor 32 and eccentric weight shafts 55 and 56. Belt 42 running up to and down from motor output pulley 40 (see FIGS. 1 and 2) has a round cross section and preferably is made of rubber or some other elastomeric material, and is installed between motor pulley 40 and pulley 44 on shaft 38 with some amount of static tension. Shaft 38 is rotatably supported in housing 36 and drives double-groove pulley 48 at its end distant from pulley 44 only when electrically actuated clutch 46 is engaged as explained above. Pulley 48 drives both of the eccentric weight shaft belts 49 and 50 running to pulleys 52 and 53 on shafts 55 and 56 respectively. The concerned belts are both shown fragmentarily in FIG. 7 and similarly to motor output belt 42 each one is preferably installed with some amount of static tension. FIG. 8 in particular shows that the groove in pulley 48 for belt 49 has a smaller pitch diameter than the groove therein for belt 50. That difference in pitch diameters causes the linear speed of belt 49 to be less than that of belt 50 with the further result that eccentric weight shaft 55 is driven somewhat slower than eccentric weight shaft 56, it being assumed that shaft pulleys 52 and 53 have essentially identical pitch diameters.

Referring next to FIGS. 9, 10, 11, 12 and 13, there are shown divider arrangements for vibratory feed hopper 22 (FIG. 9) which may be employed when the fluidized pul-

verulent material issuing from it is desired to be discharged as two streams in one case and three streams in another case. FIG. 10 illustrates that two-stream arrangement using a separator or divider device 120 which appears by itself in FIG. 11. This device has a transverse or dividing segment or portion 121 and end pieces or attachment flanges 122 and 123, flange 122 having an upward extension. There are elongated holes 124 and 125 in the flanges through which may be passed screws 114 which have passed already through holes 116 in opposite walls of feed hopper 22. Nuts 115 are applied onto those screws. Thus, as so far seen, the feed hopper may be fitted with either a four-stream divider 112 (FIGS. 2 and 6) or a two-stream divider 120 (FIG. 10) without change in the hopper itself.

FIG. 12 illustrates the three-stream arrangement using a separator or divider device 130 which appears by itself in FIG. 13. That device has transverse or dividing segments 131 and 134 and end pieces or attachment flanges 132 and 135 characterized respectively by elongated holes 133 and 136 for the passage of attachment screws 114 from feed hopper wall holes 116. Segment 131 is free at one end and may be vibrated as a cantilever similarly to the free segments of divider 112. Some vibration, although less, may be imposed upon or generated in divider segment 134 which will behave as a resilient panel anchored at opposite ends but with free edges therebetween permitting some flexure. The same situation obtains for segment 121 of two-stream divider device 120 as well as for the central one of the three parallel segments of four-stream divider device 112.

Referring finally to FIG. 14 the vibratory feeder apparatus appears fragmentarily at the left-hand side of an overall apparatus for the filling and pressing of cosmetic powder godets. The view of FIG. 14 is taken in elevation, and not all apparatus elements shown therein are at the same distance from the viewer. Relatively, the vibratory feeder apparatus including supply hopper 20, flexible collar 21, feed hopper 22 and springs 24 particularly designated is in the foreground while mechanisms and assemblies or sub-assemblies to the right thereof are in the background. The representation of the feeder apparatus is somewhat skeletonized or diagrammatic as well as being fragmented; that is, the motor and various other drive and vibration elements such as belts, weights and pulleys have been omitted to permit other elements or mechanisms to be shown clearly.

Supply hopper 20 is attached by brackets 140 and 141 to back plate 142, and its joint with or passage into feed hopper 22 is sealed by flexible collar 21 which allows the supply hopper to remain essentially stationary while the feed hopper is being vibrated. In effect, the flexible collar serves as an insulator to prevent transmission of much vibration from feed hopper 22 to supply hopper 20 while still maintaining a continuous, laterally sealed passage for pulverulent material, i.e., cosmetic powder, from one hopper into the other. Said in other words, the substantial rigidity of the supply hopper does not significantly impair the vibratory freedom of the feed hopper. Feed hopper 22 of course performs vibratory motion in six degrees of freedom on springs 24 upon motor 32 being energized with resulting rotation of eccentric weights 60. Loose, fluidized powder is delivered steadily from the bottom of the feed hopper through aperture 104 in foundation plate 26 and into one or more godets, for example four godets, disposed in and below openings or apertures 110 in turntable 144, that turntable being particularly designated and seen along its edge in FIG. 14.

A strip of material 146 permeable by air, silk being an especially suitable material, is fed from a supply roll 148 mounted on the back plate to and around a plurality of rollers and/or idlers similarly mounted, and from them is passed to and below a pressing station or apparatus 150. From there strip 146, taken to be a silk strip, is led around other rollers and/or idlers until it reaches and is wound up on takeup roll 152. The function of the silk strip is one well known in the art, namely, to serve as means through which air may escape from initially loose cosmetic powder in a godet or godets when that powder is pressed or compacted. Thus it is the silk which immediately overlies and is brought into contact with the bodies of powder in the grouped godets when turntable 144 is actuated to swing or index them around from vibratory feeder apparatus to pressing apparatus 150 and then the actual pressing elements or punches of that apparatus are lowered. Air from the powder actually escapes laterally through and along the silk strip because it can not go straight up through it on account of the solid punches above it.

Strip 146 must be advanced toward takeup roll or reel 152 occasionally to prevent it from becoming "blinded" by the pulverulent material against which it is pressed. The rate of advance of the silk will be a function at least in part of the nature of the pulverulent material or cosmetic powder being compacted. It will have to be advanced more rapidly, that is, kept fresher in way of the pressing apparatus, the higher the oil or wax content of the powders. Powders which are essentially "dry", that is, have very little oil content, will have

minimal tendency to adhere to and blind the silk. A strip of silk which has been wound up entirely onto takeup roll 152 may be removed from the apparatus altogether for cleaning and then be reinstalled at roll 148.

In the filling and compacting of cosmetic powder from feed hopper 22 into series of individual or grouped godets it is required essentially that a determined amount of powder, neither too little nor yet too much, be dispensed during the time within which an initially empty godet is positioned below the vibratory feeder apparatus in or under a turntable aperture 110 as shown in FIG. 2. In the use of turntable 144 the operation of filling godets with cosmetic powder and compacting or pressing that powder in them is of an intermittent nature as the empty godets are positioned on or in the turntable; then indexed to the feeding or filling station; then indexed to the pressing station after being filled, and then indexed to the ejecting station after being pressed. It follows that the feeding of loose, fluidized powder from hopper 22 must be intermittent also. For that reason the electrically actuated clutch 46 in the drive system from motor 32 is connected to be energized only for discrete, limited periods of time triggered by the motion of the turntable but desirably adjustable in length independently although not exceeding the dwell time of the turntable at any particular angulation.

Electric motor 32 is operated at the speed required to rotate eccentrically weighted shafts 55 and 56 at their speeds necessary for the achieving of a fluidizing frequency of vibration at and in the feed hopper and its powder contents which are replenished as required through supply hopper 20 to maintain a proper level of powder within feed hopper 22. Flywheel 47 of steadily operating motor 32 ensures that when clutch 46 is energized and engaged at the initiation of a vibratory or powder feeding period the motor is not slowed down significantly as the starting load of the eccentrically weighted shafts and their intermediate drive train comes onto it, nor allowed to speed up unduly when clutch 46 is deenergized and disengaged relieving the motor of most of its running load. Of course it is to be understood clearly that in its broader or basic concepts the present invention is not limited by the particular start-stop mechanics of the turntable described above. There is no inherent limitation on the vibratory feeder apparatus itself being fed and operated continuously so long as there be a region available into which pulverulent material fluidized in it may flow from it.

It is in all events at least desirable to provide a vibrator driving motor, i.e., electric motor 32 or its equivalent, having a variable speed since even in a given granular or pulverulent material the characteristics which make it resistant to flow, that is, those characteristics because of which externally imposed fluidization is needed, may change on account of inconsistencies of compounding or blending, changes in temperature and/or humidity, etc. Hence the fluidic vibratory frequency or blend of frequencies may change necessitating a change in motor speed. Of course the motor might be operated at a constant speed and a variable ratio transmission device or devices used in the power train or drive system to eccentrically weighted shafts 55 and 56. Weights 60 are oriented eccentrically on those shafts in relative angular attitudes determined experimentally to achieve optimum or at least a satisfactory fluidizing effect in the particular pulverulent material or powder being handled. The actual mass and extent of eccentricity of individual weights 60 are themselves variables, and in a given situation will be influenced by the mass of the feed hopper and its associated parts and contents to be vibrated and by the nature of those contents.

Since eccentrically weighted shafts 55 and 56 are driven at different, non-harmonic speeds there is a continuous wandering clash of frequencies and directions and amplitudes of vibration as the feed hopper is vibrated multidirectionally to provide fully randomized fluidization of its contents excluding the formation of standing waves of alternately active and quiescent regions in those contents. Motor 32 may drive the eccentrically weighted shafts at speeds from only about a hundred up to several thousand revolutions per minute. The weights on a given shaft may be oriented all the way from an essentially aligned condition to one in which they are practically one hundred and eighty degrees from each other, that is, out of alignment. The speed ratio of one shaft to the other may be such as 15:16 or 2:3 but to avoid standing waves shafts 55 and 56 must be rotated not only at different speeds but also at such a ratio of speeds that the higher speed is not an integral multiple of the lower speed.

Although in the preceding description of the preferred embodiment of this invention pulleys 52 and 53 are said to be of like size and pulley 48 to have grooves of different pitch diameters, it is certainly contemplated that pulley 48 may have two grooves of identical pitch diameter with the pulleys 52 and 53 being of different diameters, one with respect to the other. Whatever the arrangement, shafts 55 and 56 are to be rotated at different speeds within the limitation on speed ratios stated above, that is, no integral multiple ratios. Whether belts, roller chains, gears or other means be provided for driving and speed shifting it is

only a matter of selection in any particular practical case according to cost, space available, ease of installation, repair and replacement, and level of involved force or power transmission to name some considerations. It is to be understood also that while this invention has been illustrated and described on the basis of vibratory forces being produced by two eccentrically weighted shafts turning at different, non-multiple speeds a number of shafts greater than two may be used although there must be at least two. Considerations of relative shaft speeds pertinent for the two-shaft arrangement would continue to apply. Further, any given shaft may carry as few eccentric weights as one or any necessary or convenient number greater than two, and may even itself, if suitably mounted, perform eccentric rotation.

In particular it is desired to emphasize that while utilization of the present invention in connection with the fluidization and feeding of cosmetic powders has been illustrated, described and discussed fairly extensively that especial utilization is to be considered only representative and not limiting either specifically or to any genre of pulverulent and granular materials restricted by end use or otherwise.

WHAT WE CLAIM IS:—

1. A method for the vibratory feeding of pulverulent and granular materials, by imposing on a body of said material a vibration comprising at least two different non-harmonic frequencies, such that the material is fluidised and can be fed in a substantially liquid-like manner.

2. A method for the vibratory feeding of pulverulent and granular materials, by imposing a first vibratory frequency upon a body of said material in a hopper mounted for movement with six degrees of freedom, and simultaneously imposing at least a second vibratory frequency upon said body of material, the frequencies being different and non-harmonic, such that the material is fluidised and can be fed in a substantially liquid-like manner.

3. A method according to claim 2 in which the imposition of said vibratory frequencies upon said body of material is effected only intermittently and for selected periods of time whereby determined amounts of said body of material are caused to flow from time to time.

4. A method according to claim 2 in which vibratory effects are imposed upon said body of material both internally and externally thereof.

5. Apparatus for the vibratory feeding of pulverulent and granular materials, said apparatus comprising (1) a hopper disposed to be supplied with and at least transiently contain pulverulent or granular materials and having a lower end in which there is an outlet opening through which said materials may be discharged; (2) resilient support means for said hopper so configured to permit the hopper to be vibrated in six degrees of free movement, and (3) means for imposing vibration comprising at least two different non-harmonic frequencies upon said hopper and through it upon granular or pulverulent material contents thereof causing said contents to be fluidised whereby said material is induced to feed to and discharge from said outlet opening of said hopper in a substantially liquid-like manner.

6. Apparatus for the vibratory feeding of pulverulent and granular materials, said apparatus comprising (1) a hopper disposed to be supplied with and at least transiently contain pulverulent or granular materials and having a lower end in which there is an outlet opening through which such materials may be discharged; (2) resilient support means for said hopper so configured to permit the hopper to be vibrated in six degrees of free movement; (3) at least two eccentrically weighted shafts (4) bearing mountings wherein said shafts are rotatably supported, said mountings being disposed in substantially fixed, force-transmitting relationship to said hopper and able to vibrate and be vibrated with said hopper in its several degrees of free movement, and (5) means for rotating said shafts simultaneously at different non-harmonic speeds, whereby on account of forces generated by the eccentric weighting of said shafts at least two different non-harmonic frequencies of vibration are imposed at once upon said hopper and through it upon granular and pulverulent material contents thereof causing said contents to be fluidised whereby said material is induced to feed to and discharge from said outlet opening of said hopper in a substantially liquid-like manner.

7. Apparatus according to claim 6 in which said resilient support means comprise (1) a support plate fixed on said hopper and extending outwardly therefrom; (2) a foundation plate below said support plate, and (3) a plurality of springs disposed between said foundation plate and said support plate, and in which said bearing mountings for said eccentrically weighted shafts are located on said support plate.

8. Apparatus according to claim 6 in which said means for rotating said eccentrically weighted shafts comprise (1) a variable speed motor, and (2) a power train whereby said motor is connected to both of said shafts, said power train including pulley means having belt grooves of different pitch diameters associated one diameter with the immediate drive of one shaft and the other diameter with the immediate drive of the other shaft whereby the different

non-harmonic speeds of said shafts are caused.

9. Apparatus according to claim 6 in which said means for rotating said eccentrically weighted shafts comprise (1) a variable speed motor, and (2) a power train whereby said motor is connected to both of said shafts, said power train including a selectively engageable and disengageable clutch by means of which said motor may be allowed to run continuously while said eccentrically weighted shafts are caused to be rotated and said hopper and its contents vibrated only for limited and chosen periods of time.

10. Apparatus according to any one of claims 6 to 9, further comprising divider means within said hopper near said outlet opening thereof whereby material discharging from said hopper is separated into at least two streams, said divider means being of resilient material and susceptible to being vibrated along with said hopper and the contents thereof whereby additional vibration is imposed upon and additional fluidisation is achieved in such contents.

11. Apparatus according to claim 10 in which said divider means includes at least one dividing element free at one end and disposed to vibrate and be vibrated as a cantilever.

12. Apparatus according to claim 10 in which said divider means is limitedly adjustable as to vertical position within said hopper.

13. A method for the vibratory feeding of pulverulent and granular materials, the method being substantially as hereinbefore described with reference to the accompanying drawings.

14. Apparatus for the vibratory feeding of pulverulent and granular materials, the apparatus being substantially as hereinbefore described with reference to the accompanying drawings.

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1401446 COMPLETE SPECIFICATION

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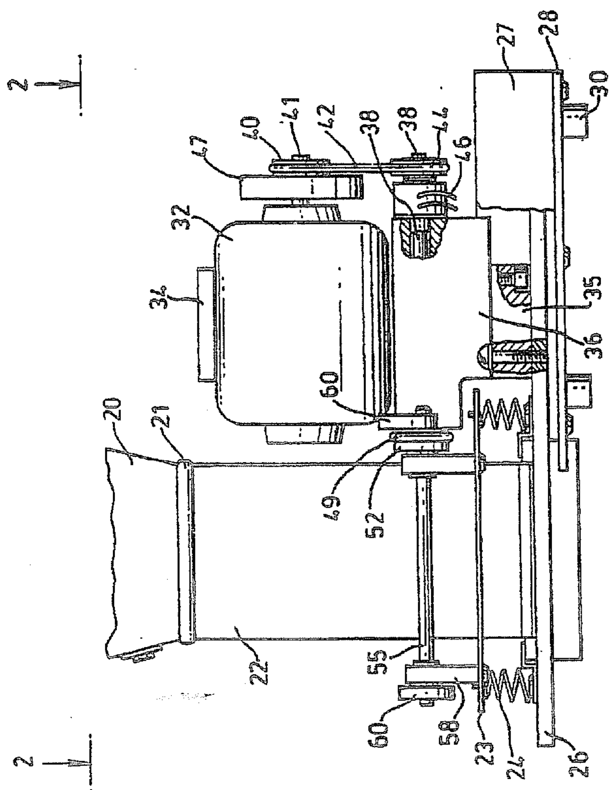

FIG. 1.

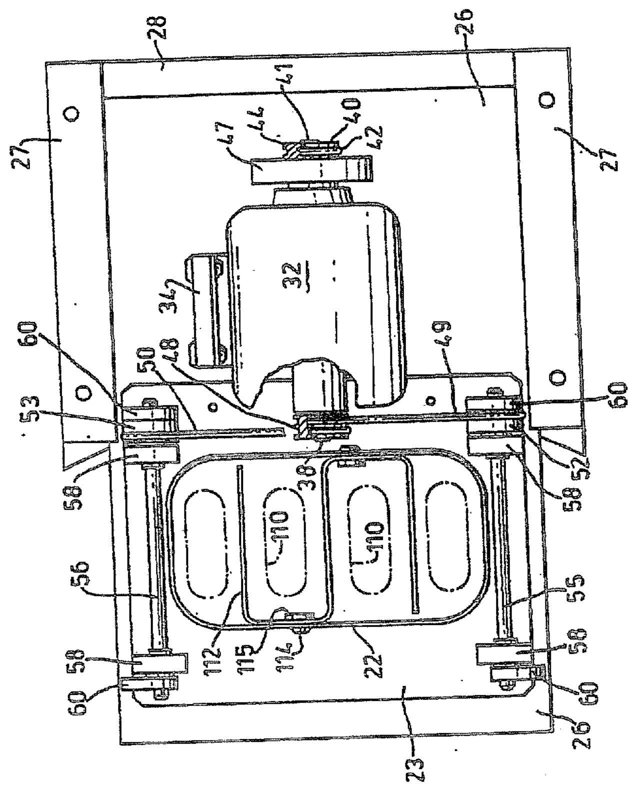
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FIG. 2.

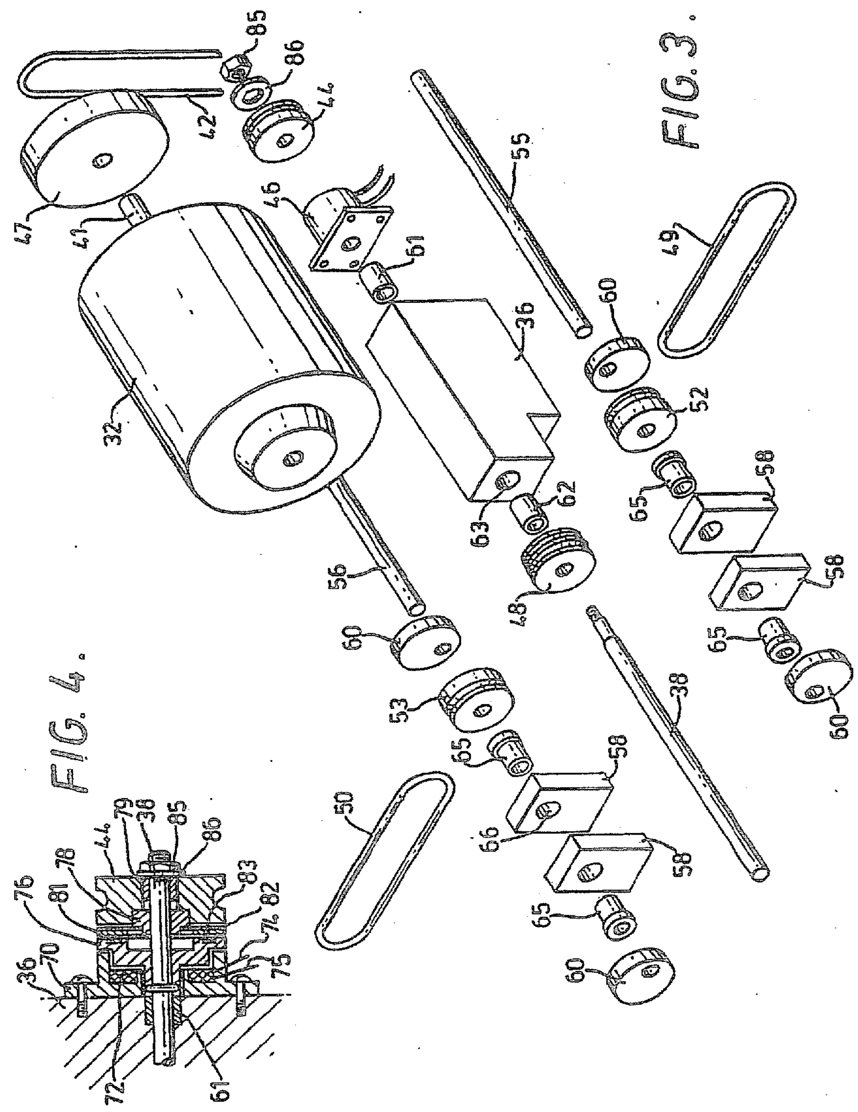
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FIG. 3.

FIG. 4.

1401446 COMPLETE SPECIFICATION

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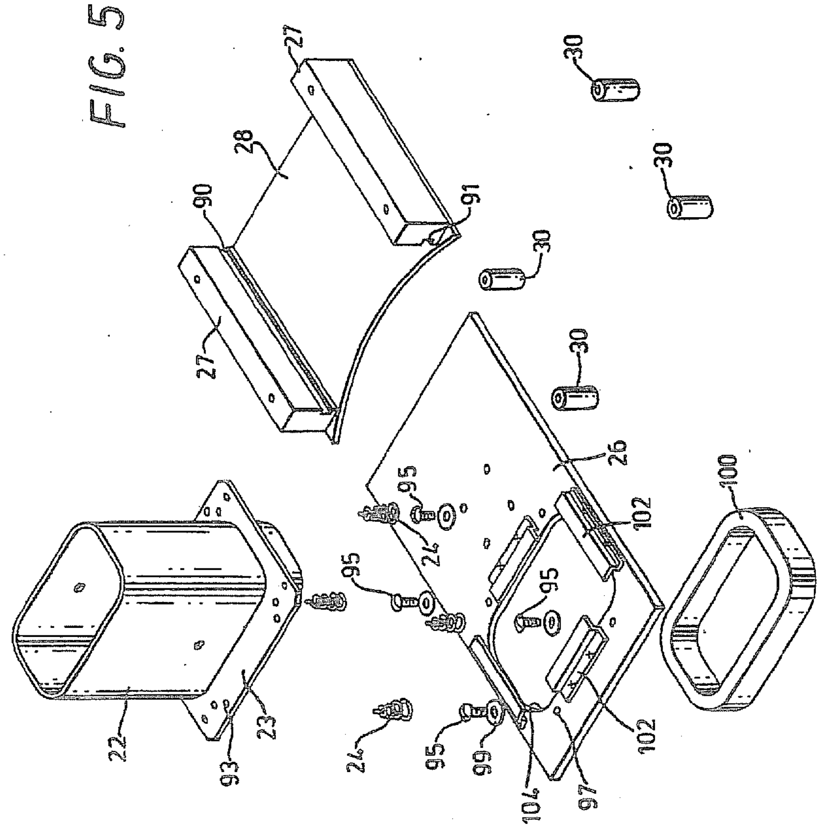
Sheet 4

FIG. 5.



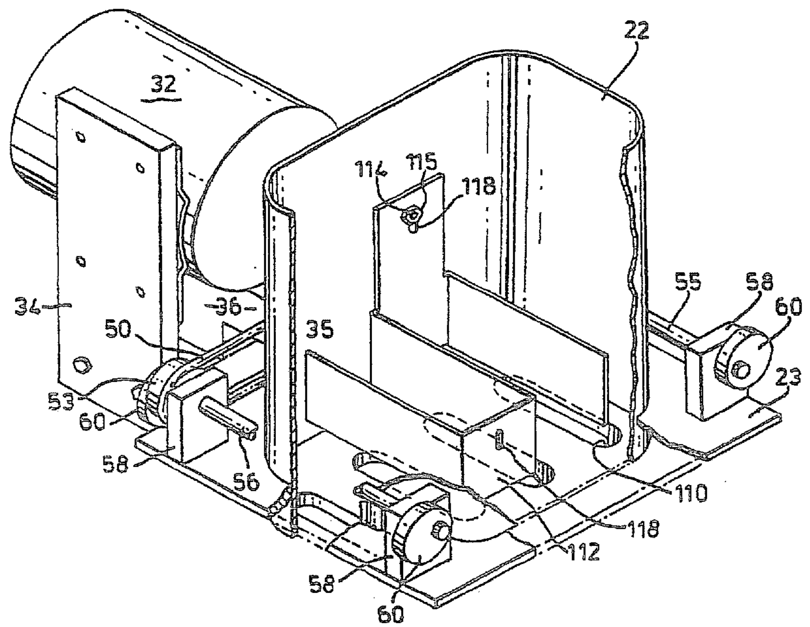

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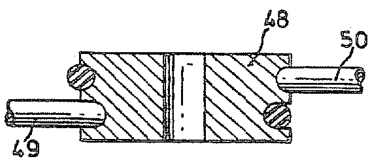
FIG. 6.



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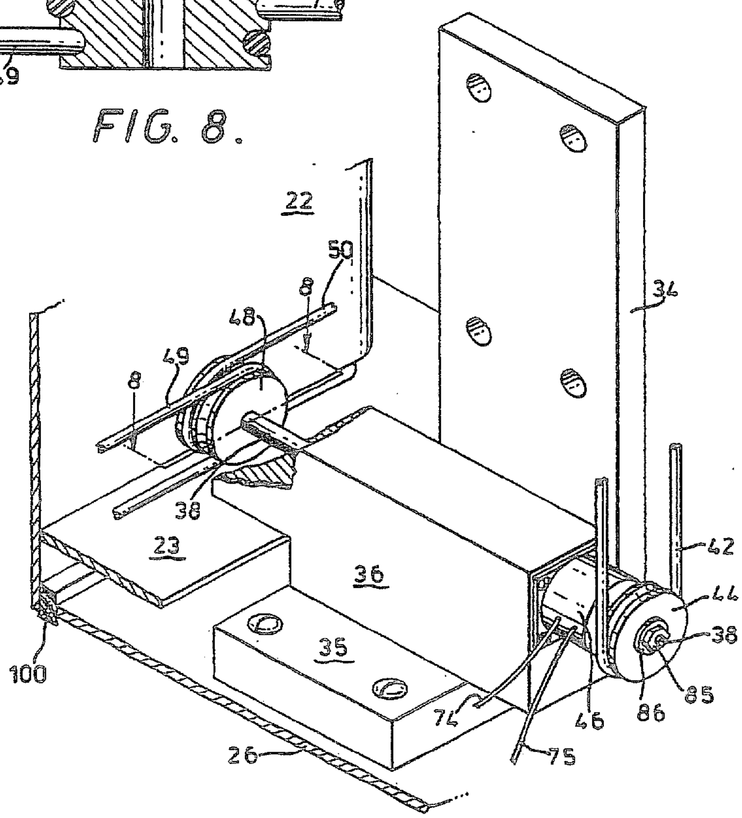

FIG. 7.

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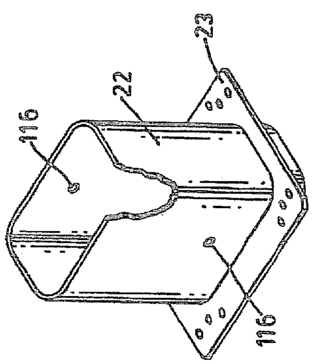
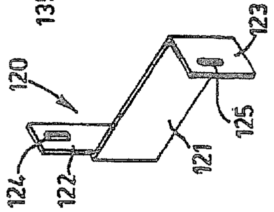


FIG. 9.



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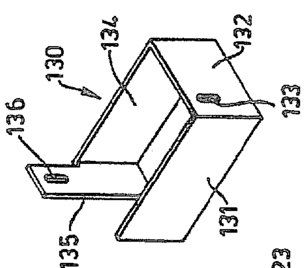

FIG. 13.

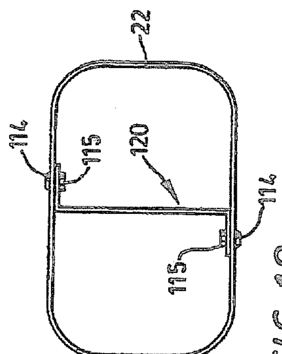

FIG. 10.

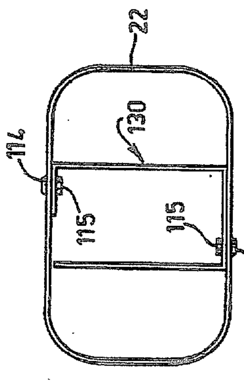

FIG. 12.

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Sheet 8

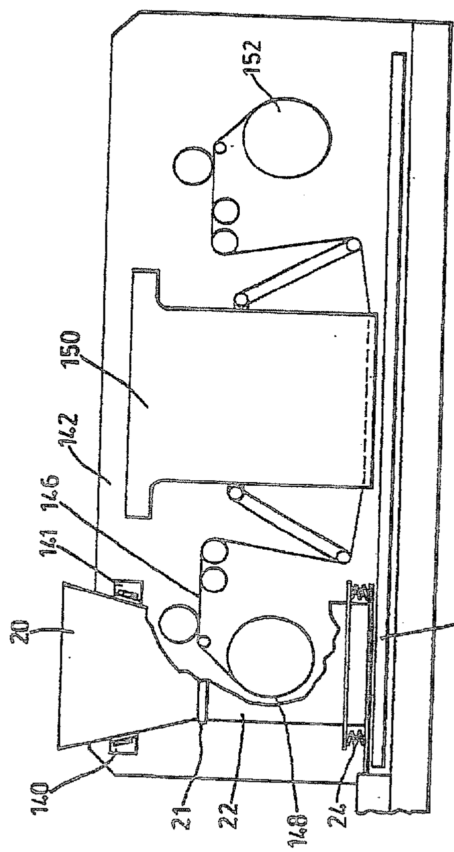

FIG. 14.